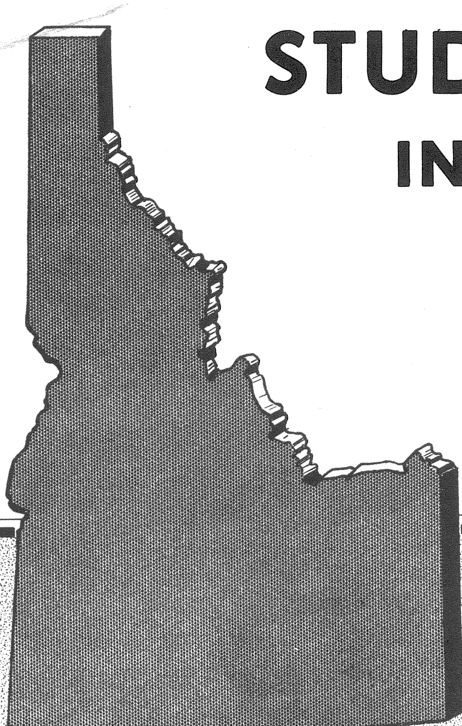
PAVEMENT DAMAGE FROM USE OF STUD EQUIPPED TIRES

INTERIM REPORT

JANUARY 1966

IDH-RP036-INT



RESEARCH PROJECT NO. 36

STATE OF IDAHO DEPARTMENT OF HIGHWAYS

A STUDY OF PAVEMENT DAMAGE FROM THE USE OF STUD EQUIPPED TIRES

Interim Report

RESEARCH PROJECT NO. 36

January, 1966

Maintenance Division
and Research Division

State of Idaho
DEPARTMENT OF HIGHWAYS
Boise, Idaho

ACKNOWLEDGMENTS

Ray Lower, Transportation Officer, abstracted most of the research reports of other agencies. Kenneth Ward, Special Maintenance Superintendent, and Stanley Lindauer, Equipment Clerk, assisted L. F. Erickson, Research Engineer, with the skids tests conducted by the Idaho Department of Highways.

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A STUDY OF PAVEMENT DAMAGE FROM USE OF STUD EQUIPPED TIRES

Introduction

Studded tires have been used in several European countries for at least five years and were introduced into Canada and the United States in the 1964-65 winter season.

A studded tire is a snow tire which has been equipped with inserts of tubular steel, aluminum or plastic which have a center core of tungsten carbide. The studs vary somewhat between manufacturers but are generally cylindrical in shape with a flange at the base to hold them in the tire tread. They are inserted into the tread of the tire in holes pre-molded at the tire factory. An air gun is used to force the studs into the holes and the stud is intended to remain in place for the life of the tire with the stud expected to wear at approximately the same rate as the tire rubber. The tungsten carbide core for passenger car tires is approximately 0.08 inches in diameter and is encased in a flanged sheath about 0.25 inches in diameter. The studs may vary in length from less than 1/2 inch for some of the tires of smaller cars to almost an inch for truck tires. They are mounted in the tread generally with the tip protruding from 1/32 to 1/16 inch above the tread surface. The number of studs per tire in American cars varys from about 75 to 150 depending upon tire size.

Some of the major tire manufacturers expect 15 per cent of next winter's snow tires to be "pinned", (manufactured with the pre-molded holes for studs). As of July 1965 studded tires could be used in 26 of the States and the District of Columbia, they were not permitted in 15 States, and their permissible use was undetermined in 8 States.

W. P. Miller II, Automobile Tire Engineering, Goodyear Tire and Rubber Company, advised some 20 different types of studs were being marketed in the United States. Forecasts for 1965 and 1966 project a production of 500,000 to 1,000,000 studs per day with anticipated total production of 100,000,000 compared to 25-30,000,000 sold last season. All major tire companies will produce a winter tread with premolded holes for insertion of studs.

Mr. Joseph P. Kigin, Legislative Assistant, Rubber Manufacturers Association, reported there were 121,890,000 passenger tires produced in 1963 of which 11,305,000 were winter tires or approximately 10 per cent.

Mr. Bert Colley, Portland Cement Association, compared concrete wear under the action of chains, studded tires, and an E-17 tire. Research lead him to believe there will be no difference in wear due to aging of concrete, that poor aggregates may adversely affect wear, that little wear will be attributable to the use of air entrained concrete, and "polishing" may become a factor as fines are removed from the surface.

Table I and II, Appendix A, list states and countries where studded tires are or are not permitted. Some permit their use during winter months making them illegal during other times of the year. Several states have authorized their use temporarily to determine the effect on roadway surfaces and may later revoke permission for their use.

Abstracts of several research reports are included in Appendix B. These tests were generally run during the past season and many additional tests will be conducted this 1965-66 winter.

<u>Advantages from the use of stud equipped tires</u>

Several advantages are set forth from tests for stud equipped tires. Tests indicate:

1. Increased traction (pulling power) for tires having stud inserts.
2. Studded tires reduces stopping distances when compared to standard tires of the same make on same weight vehicle at the same speed.
3. Maneuverability of a vehicle is increased on hard packed snow for starting, stopping and cornering compared to a like vehicle traveling at the same speed but without studded tires.

Disadvantages from the use of stud equipped tires

Several disadvantages are evident from the use of studded tires. These are:

1. Safe driving with stud equipped tires is dependent on reduced speeds and cautious driving comparable to driving without studded tires. It is human nature to drive "road conditions" and since studded tires will reduce spinning of wheels and slippage, speeds will increase. EVEN A MODERATE INCREASE IN SPEED WILL ELIMINATE ALL INCREASED SAFETY FROM THE USE OF STUDDED TIRES.
2. Tire chains were more effective than studded tires in stopping and traction. Tire chains showed a 400 per cent improvement whereas studded snow tires gave 136 per cent improvement and snow tires only 36 per cent improvement over standard tires.

Conclusions

1. Studded tires are helpful only if the driver exercises all normal cautions that are expected when driving under adverse

weather conditions.

2. Some drivers will find them advantageous, others will not and it is unknown what percentage vehicles may use studded tires.
3. Damage to pavements is significant depending on the volume of studded tire equipped vehicles, length of normal usage, amount of ice and snow covering pavement, etc.
4. Pavement damage is most prevalent where stopping, starting, accelerating, cornering or similar vehicle maneuvers are common.
5. The concensus of opinions reported by researchers is to the effect that only by actual use can the full significance of pavement damage be determined. Low traffic volume highways will probably not be affected whereas high traffic volume urban streets at intersections requiring stopping will show perhaps significant damage.

Recommendations

1. Continue gathering reports of research by others.
2. Continue observing conditions of streets which may show evidence of damage and if evident try to obtain estimates of traffic volume using studded tires.
3. Discontinue any further testing by Department of Highways of studded tires.

APPENDIX A

TABLE I

STATES WHERE STUDDED TIRES ARE PERMITTED

Alaska	Massachusetts	North Dakota
Colorado (1)	Minnesota (1)	Ohio
Connecticut	Montana	Pennsylvania
Delaware	Nebraska (1)	Rhode Island
Washington, D. C.	Nevada	South Dakota
Idaho (1)	New Hampshire	Vermont
Kansas (1)	New Jersey	Washington
Maine (1)	New York	Wyoming
Maryland (1)	North Carolina	

STATES IN WHICH STUDDED TIRES ARE NOT PERMITTED

Alabama	Indiana	Oregon
Arizona	Iowa	South Carolina
California	Louisiana	Virginia
Georgia	New Mexico	West Virginia
Illinois	Oklahoma	Wisconsin

Michigan and Utah have legislation pending which would permit use of studded tires.

STATES IN WHICH PERMISSIBLE USE IS UNKNOWN

Arkansas	Kentucky	Tennessee
Florida	Mississippi	Texas
Hawaii	Missouri	

(1) Legislation authorizing use of studs in tires passed at the last legislative session in that state (probably 1965).

TABLE II

FOREIGN COUNTRIES

PERMITTING USE OF STUDDED TIRES

Canadian Provinces	Germany (Prohibited in Summer)
Switzerland (Prohibited in Summer)	Norway

DO NOT PERMIT USE OF STUDDED TIRES

France
Luxemborg

APPENDIX B

STATE OF IDAHO
DEPARTMENT OF HIGHWAYS

Test of tires with tungsten carbide stud inserts, steel wire embedded in tread and chains.

Each car, 1964 Ford Sedan, had ordinary highway tread tires in front, snow tread in rear, 7x50 x 14 tires.

Car No. 1 - Tungsten carbide studs, all four tires
Car No. 2 - Wire inserts, all four tires
Car No. 3 - No inserts, plain tires
Car No. 4 - Chains on rear only

Skid Tests - Panic Stops

Three drivers each making panic stops, stopping distances in feet:

	Plain Tire	Chains	Wire Insert Recap	Studs
No. 1 Snow floor - icy - wet (20 mph)				
Driver 1	49		55	48
2	61		64	49
3	78		96	69
No. 2 Black ice - wet - some slush (20 mph)				
Driver 1	45	37	35	24
2	44	44	31	29
3	47	71	52	39
No. 3 Black ice - wet - slushy (30 mph)				
Driver 1	94	90	77	78
2	102	99	89	89
3	100	120	107	120
No. 4 Black ice - wet - slushy (45 mph)				
Driver 1	-	148	-	-

Maintenance Engineer's car with tungsten carbide inserts showed condition of tires after 4,000± miles of highway driving mostly on bare pavement.

Front tires had 82 studs
Snow tires had 102 studs

No. 1 Front had 13 loose studs, 3 broken, 3 missing
No. 2 Front had 7 loose studs, 2 broken, 1 missing
No. 1 Rear had 2 loose studs, 17 broken, 0 missing
No. 2 Rear had 2 loose studs, 13 broken, 0 missing

Tires were dished or flat between studs - wear was greater between studs than near stud.

ILLINOIS
"Effect of Studded Tires on Pavement Surfaces"
Department of Public Works and Buildings,
Division of Highways, Bureau of Research and Development, March 1965

Tests were made to obtain information on the likely effects of studded tires on dry pavement surfaces. Three types of pavement were available for testing. Portland cement concrete and bituminous concrete surfaces were subjected to starting, stopping and constant speed tests. Stops and starts were both normal and emergency. Turning tests were also made on bituminous concrete surfaces. Approximately 275 applications, or vehicle passes, were made in each of the above categories. Bituminous surface treated pavement was also subjected to 25 emergency starts followed by 25 emergency stops.

The tests showed that studded tires caused a slight abrasive effect on all surface types during normal driving and a pronounced abrasion under emergency stop and start conditions. Abrasion depths up to 1/16 inch were measured after a combination of 25 emergency stops and 25 quick starts on concrete pavement. Bituminous surface treated pavement showed the most pronounced damage during the tests.

Tests made to obtain information on the relative stopping distances required by vehicles mounted on studded tires and on regular tires. These tests were undertaken after abrasion tests and indicated greater instances were required to stop on studded tires on a dry portland cement concrete surface. Stops were made from speeds of 10, 20 and 30 miles per hour. Three tire combinations were used: four studded tires, studded rear and regular front tires, and four regular tires. Each tire combination was tested five times at each of the three speeds for a total of 45 individual test runs.

These tests resulted in stopping distances ranging up to 9 per cent greater for the combination having studded tires on the rear and up to 23 per cent greater stopping distance when studded tires were used on all four wheels.

MARYLAND

Maryland HPS-HPR-1(27) Program
"Effects of the Use of Carbide Studded Tires on Roadway Surfaces"
Maryland State Roads Commission in Cooperation With U. S. Bureau of Public Roads
Allan Lee, Chief, Bureau of Research
Reported by Thomas A. Page, Bureau of Research, April 1965

Tests were made on separate test loops with passenger type studded tires and studded truck tires. Passenger tires had 104 studs per tire, truck tires had 110 studs per tire. A total of 10,000 circuits were made at each of the test loops, both of which included flexible and rigid pavement. Three measurement sites were selected for each pavement type on each test loop and each measurement site included five transverse lines at which measurements were taken before the test and at approximately 2000 loop intervals.

After about 4800 circuits of the passenger tire loop new tires were installed because only 20 per cent of the original carbide studs remained. At the end of the remaining 5200 circuits about 23 per cent of the studs remained in the passenger tires. Truck tires were rotated at 500 mile intervals and four of the original truck tires were replaced during the test. At the end of the test approximately 70 per cent of the truck tire studs remained. The range of wear of the truck tires was from 0.050 to 0.174 inches on flexible pavement and from 0.022 to 0.170 inches on rigid pavement. On the passenger tire test loop the range of wear was from 0.028 to 0.107 inches on flexible pavement and from 0.013 to 0.052 inches for the rigid pavement. Damage was considered to be significant.

MINNESOTA
"Effect of Studded Tires on Highway Pavements"
Minnesota Department of Highways
Special Study No. 290

Tests were conducted on concrete pavement and asphalt pavement making tests of abrupt starting and accelerations, normal starting and accelerations, severe braking and normal braking tests. Little to no damage could be determined for normal starting, accelerating or stopping operations. Repetitions of severe braking and panic stops did produce gouges in concrete pavements. Abrupt starting and accelerations caused similar gouges. Similar results were obtained for tests on asphalt pavements. Photographs with the report show definite abrasions on both concrete and asphalt pavements with severe and panic braking stops.

Minnesota reports that some moderate damage can be expected in urban areas. They have no way of predicting the severity of the damage.

NEW YORK
"Effect of Studded Tires on Skid Resistance and Pavement Wear"
New York State Department of Public Works, Bureau of Physical Research, May 1965

Tests were made to investigate the ability of tungsten carbide studs to increase traction of tires on ice and snow packed roads and also to determine the effect of the studs on bare pavements in regard to traction and the extent of pavement damage. Tests were performed with two similar snow tires, one with tungsten carbide studs and one without the studs. A skid trailer was used with which it was possible to lock one wheel while traveling at a constant speed to compare the resultant drag forces. A total of more than 100 tests were made on new and old bituminous and concrete pavements and on wet, dry, icy and snow-packed surfaces.

Test results show the studded tire had approximately 40 per cent increased traction on ice and about 9 per cent increased traction on snow-packed surfaces. Traction was increased about 4 per cent on both concrete and bituminous pavements while wet and about a 1 per cent increase of traction on dry bituminous pavements with no effect on dry concrete surfaces. All road surfaces tested were slightly scratched by the tire studs but damage to pavement was not considered to be significant.

OREGON
"Tests of Steel Studded Snow Tires"
Materials Division, Oregon State Highway Department
Oscar A. White, Engineer of Materials and Research

Two types of tests to determine damaging effect to highway surfaces of studded tires were made. Spin tests were made in which one wheel of the drive axle of a stationary (blocked) vehicle was jacked up and while turning at 500 rpm was lowered to the test pavement to a load of 500 pounds and spun for 20 seconds. Three types of pavements were tested: portland cement concrete, asphaltic concrete and bituminous macadam. The spin tests were made using studded tires, tire chains on regular tires, and snow-grip rubber tread under conditions of dry, wet, and snow-packed surfaces. A second test was made involving 5330 trips over a figure 8 route with a vehicle having studded tires front and rear on the left side and ordinary snow tires front and rear on the right side. Results of the spin test revealed the studded tires produced greater damage to portland cement concrete than tire chains but tire chains produced greater damage to asphaltic concrete. Average depth of scour for studded tires on portland cement concrete in the spin test was 0.17 inches compared to 0.12 inches for tire chains. On asphaltic concrete the tire chains procuded damage to an average depth of 0.69 inches compared to 0.36 inches for studded tires. On bituminous macadam the averages were 0.48 inches for tire chains compared to 0.40 inches for studded tires. On both the asphaltic concrete and bituminous macadam pavements the studded tires in the spin test produced approximately twice the depth of scour as the rubber treaded snow tire.

The multiple trip tests were conducted on an asphaltic concrete surface and resulted in measurable wear. Assuming 25 per cent of vehicles are equipped with studded tires, and assuming the same quality asphaltic concrete as in the test track, the wear measured in the test track could be equaled in 60 days on the Salem - Portland Freeway.

PENNSYLVANIA
Research Project No. E-64-19, "Carbide-Studded Tires"
Pennsylvania Department of Highways, Bureau of Materials Testing and Research
R. K. Shaffer, Research Coordinator, November 1964

Purpose of this project was to determine comparative effect of chains and studded tires. Tests were conducted on both bituminous and cement concrete surfaces and included normal acceleration, normal stopping, "spin-out" acceleration and "panic" stopping. Tests were made first with studded tires and then with non-cleated chains on standard tires.

In normal acceleration and stopping, the marks left on the pavement by the studs varied from indiscernible (stopping) to barely visible (acceleration). The effects of the chains were slightly more prominent. In spin-out and panic stop tests, the studded tires scarred pavement surfaces with long etched marks but it was impossible to feel any impression caused by the studs. Damage caused by spinning (and locked) tires with chains appeared more pronounced but did not feel any worse on close inspection. In either case damage seemed superficial during the tests although under concentrated flow of traffic in confined areas, repeated loads could wear into the pavement.

NATIONAL SAFETY COUNCIL
Traffic Safety Department
425 N. Michigan Avenue, Chicago, Illinois

Tests conducted by the Committee on Winter Driving Hazards of the National Safety Council were reported by Committee Chairman Professor A. H. Easton. Tests were conducted at ice temperatures ranging from 18 degrees below to zero to 32 degrees with considerable variation being caused by such factors as air temperatures, ice temperatures, solar radiation and wind velocity. The averaged test results gave snow tires a 36 per cent improvement in traction (pulling ability) over the conventional highway tread while studded snow tires improved traction by 136 per cent and reinforced tire chains improved traction over conventional tires by 405 per cent. Braking tests resulted in the following averaged stopping distances for a car traveling at 20 miles per hour on ice: with reinforced tire chains, 70 feet; with studded snow tires, 110 feet; with snow tires, 167 feet; with regular tires, 180 feet.

GERMANY
"Pavement Wear Due to Use of Winter Tires With Spikes"
by Professor Dr. Ing B. Wehner, Germany

Research reported states that vehicles equipped with studs had better braking and driving control in wintry and slippery streets and curves. Skid resistance on glare ice is improved. Damage to asphalt pavement cores set in concrete pavement was evident after 5000 passes of a wheel. Wear to the surface varied with the type of surfacing with new pavements not previously exposed to traffic showing about 1½ times the wear than pavements having been exposed to traffic. Wear measurements ranged from about 0.03 inches to 0.06 inches.

SWEDEN
"Investigation of Friction Properties of Winter Tires and Anti-Skid Devices"
by G. Kullberg Och B Kihlgren
Swedish Road Institute

This investigation was undertaken to determine the grip of a tire to the road covered with ice and snow. All road conditions were tested from loose or compacted snow to ice and snow covered ice. The tests showed that on icy roads all types of tires had a bad grip on the road. Studded tires increased the grip to some extent. Chains on the other hand gave an appreciable improvement on ice. Friction between tire and road is lower in all cases than during summer driving on dry pavements. They warn "the only way to reduce the risk of skid accidents in the winter" is to adapt the speed and manner of driving according to road conditions. This means that the speed on winter roads as a rule must be reduced considerably.

FAGERSTA STEELS LIMITED OF TORONTO, ONTARIO
Seco Studs, Tungsten Carbide Studs
An Evaluation of Tire-Studding Techniques

A study was made by Fagersta Steels Limited of investigations which had been made by various motoring organizations and tire manufacturers in Sweden, Norway and Finland of the safety benefits of studded tires. These tests had demonstrated that studded tires provide a grip on icy road surfaces of from 30 to 50 per cent better than regular snow tires. Results of these tests have varied because of the influence of several factors.

Temperature would influence test results because ice becomes more solid with decrease in temperature.

The tire studs should protrude approximately 1/16 inch from the tread surface. A greater protrusion will cause excessive stud wear and the loss of studs.

Studs should be arranged in a pattern which will allow as many studs as possible to exert a maximum pressure while braking or accelerating. The leading stud of studs arranged in a row will exert a maximum effect while other studs in the same row will be less effective. Studs should be arranged in as many rows as possible depending upon tread design. Tests revealed that tires with 192 studs arranged in four rows were only slightly more effective than tires with 96 studs arranged in four rows. But tires with 192 studs arranged in a tread pattern having 12 rows was 50 per cent more effective that the tire having 96 studs, or 192 studs, in four rows. At least 5 studs per tire per 100 pounds of vehicle weight deployed in as many different lines as the tread pattern will permit are recommended for efficient normal use.

FAGERSTA BRUKS AB OF SWEDEN
(Manufacturer and marketer of Seco, Secomet and Kometa Tire Studs)

SECOMET, THE TYRE STUD WITH TUNGSTEN CARBIDE CORE
Basic Facts Regarding the Function of Tyre Studs

Wear rate of tire studs should conform to the wear rate of tire rubber during the life of the tire for satisfactory service. Tests by Fagersta Steelworks reveal that the Secomet tire studs have a wear rate greater than rubber at speeds below 50 km, about 30 mph, about the same wear rate within a range of 80-90 km, about 50-55 mph, and the wear rate of rubber is about 20 per cent greater than the studs at a speed of 110 km or 70 mph. Speed, and the heat generated by speed, increases the wear rate of rubber but has little affect on the wear rate of the tungsten carbide studs.

Tests by Fagersta show that studs mounted in the center of the tire should protrude from 0.5 to 1.0 mm and on the shoulder the protrusion should be between 2.0 and 2.5 mm for best long term effect. Greater protrusions will cause early loss of the studs. The studs should be mounted at right angles to the wheel axis rather than at right angles to the tread surface.